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UMTRA PROJECT WATER SAMPLING AND ANALYSIS PLAN

GUNNISON, COLORADO

June 1994

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UMTRA PROJECT
WATER SAMPLING AND ANALYSIS PLAN
GUNNISON, COLORADO

June 1994

Prepared for
U.S. Department of Energy
UMTRA Project Office
Albuquerque, New Mexico

Prepared by
Jacobs Engineering Group Inc.
Albuquerque, New Mexico

EXECUTIVE SUMMARY

This water sampling and analysis plan summarizes the results of previous water sampling activities and the plan for water sampling activities for calendar year 1994. A buffer zone monitoring plan is included as an appendix. The buffer zone monitoring plan is designed to protect the public from residual contamination that entered the ground water as a result of former milling operations.

Surface remedial action at the Gunnison Uranium Mill Tailings Remedial Action Project site began in 1992; completion is expected in 1995. Ground water and surface water will be sampled semiannually in 1994 at the Gunnison processing site (GUN-01) and disposal site (GUN-08). Results of previous water sampling at the Gunnison processing site indicate that ground water in the alluvium is contaminated by the former uranium processing activities. Background ground water conditions have been established in the uppermost aquifer (Tertiary gravels) at the Gunnison disposal site.

Water sampling is scheduled for March/April 1994 and October 1994. Water quality sampling is conducted at the processing site 1) to ensure protection of human health and the environment, 2) for ground water compliance monitoring during remedial action construction, and 3) to define the extent of contamination. At the disposal site, sampling is conducted to comply with the surface remediation ground water protection strategy presented in the *Remedial Action Plan and Site Design for Stabilization of the Inactive Uranium Mill Tailings Site at Gunnison, Colorado* (DOE, 1992a).

The monitor well locations provide a representative distribution of sampling points to characterize ground water quality and ground water flow conditions in the vicinity of the sites. The list of analytes has been modified with time to reflect constituents that are related to uranium processing activities and the parameters needed for geochemical evaluation. Water sampling will be conducted at least semiannually during and one year following the period of construction activities, to comply with the ground water protection strategy discussed in the remedial action plan (DOE, 1992a).

TABLE OF CONTENTS

Section	Page
EXECUTIVE SUMMARY	ES-1
1.0 INTRODUCTION	1-1
1.1 Purpose	1-1
1.2 Site location	1-1
1.3 Site history	1-4
1.4 Site status	1-4
1.5 Sampling plan	1-5
2.0 GUNNISON PROCESSING SITE	2-1
2.1 Site conceptual model	2-1
2.1.1 Physiographic setting	2-1
2.1.2 Geology	2-1
2.1.3 Hydrology	2-6
2.1.4 Water quality	2-8
2.2 Data collection objectives	2-10
2.2.1 Regulatory requirements	2-15
2.2.2 Compliance monitoring	2-15
2.2.3 Site characterization	2-15
2.2.4 Risk assessment	2-15
2.3 Water sampling plan	2-16
2.3.1 Sampling locations	2-16
2.3.2 Constituent selection	2-20
2.3.3 Sampling frequency	2-21
2.3.4 Data interpretation	2-22
2.3.5 Anomalous data evaluation	2-23
2.3.6 Plan modifications and termination of monitoring	2-23
3.0 GUNNISON DISPOSAL SITE	3-1
3.1 Site conceptual model	3-1
3.1.1 Physiographic setting	3-1
3.1.2 Geology	3-1
3.1.3 Hydrology	3-6
3.1.4 Water quality	3-6
3.2 Data collection objectives	3-8
3.2.1 Regulatory requirements	3-8
3.2.2 Compliance monitoring	3-8
3.2.3 Site characterization	3-8
3.3 Water sampling plan	3-10
3.3.1 Sampling locations	3-10
3.3.2 Constituent selection	3-11
3.3.3 Sampling frequency	3-11
3.3.4 Data interpretation	3-11

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Page</u>
3.3.5 Anomalous data evaluation	3-12
3.3.6 Plan modifications and termination of monitoring	3-12
4.0 LIST OF CONTRIBUTORS	4-1
5.0 REFERENCES	5-1
APPENDIX - BUFFER ZONE MONITORING PLAN FOR THE DOS RIOS SUBDIVISION	

LIST OF FIGURES

Figure		Page
1.1	Location of processing and disposal sites, Gunnison, Colorado	1-2
1.2	Area of water quality monitoring in the processing site vicinity, Gunnison, Colorado	1-3
2.1	Water quality sampling locations in the vicinity of the processing site, Gunnison, Colorado	2-2
2.2	Geologic cross section (northeast - southwest) of the processing site vicinity, Gunnison, Colorado	2-5
2.3	Water table contour map for the alluvial aquifer (intermediate wells) at the processing site, Gunnison, Colorado	2-7
2.4	Uranium concentrations in alluvial ground water (intermediate wells) at the processing site, Gunnison, Colorado	2-11
2.5	Sulfate concentrations in alluvial ground water (intermediate wells) at the processing site, Gunnison, Colorado	2-12
2.6	Uranium concentrations versus time in selected background, plume, and downgradient monitor wells at the processing site, Gunnison, Colorado	2-13
2.7	Sulfate concentrations versus time in selected background, plume, and downgradient monitor wells at the processing site, Gunnison, Colorado	2-14
3.1	Location of monitor wells in the disposal site vicinity, Gunnison, Colorado	3-2
3.2	Geologic cross section (north-south) of the disposal cell vicinity, Gunnison, Colorado	3-5
3.3	Potentiometric surface of the uppermost aquifer (Tertiary gravels) at the disposal site, Gunnison, Colorado	3-7

LIST OF TABLES

<u>Table</u>	<u>Page</u>
2.1 DOE monitor well information for the Gunnison UMTRA Project processing site, Gunnison, Colorado	2-3
2.2 Analytical constituents measured for baseline water quality screening	2-9
2.3 DOE monitor well sampling locations for the Gunnison UMTRA Project processing site and vicinity	2-17
2.4 Private well sampling locations downgradient from the Gunnison processing site	2-19
2.5 Surface water sampling locations in the vicinity of the Gunnison processing site	2-20
3.1 DOE monitor well information for the Gunnison UMTRA Project disposal site, Gunnison, Colorado	3-3
3.2 Summary of background ground water quality and proposed concentration limits for the Gunnison UMTRA Project disposal site	3-9
3.3 DOE monitor well sampling locations for the Gunnison UMTRA Project disposal site and vicinity, Gunnison, Colorado	3-10

LIST OF ACRONYMS AND ABBREVIATIONS

<u>Acronym</u>	<u>Definition</u>
ac	acre
ASER	annual site environmental report
CDH	Colorado Department of Health
cm/s	centimeters per second
DCO	data collection objective
DOE	U.S. Department of Energy
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
ft	foot
ha	hectare
km	kilometer
m	meter
m ³	cubic meter
MCL	maximum concentration limit
mg/L	milligrams per liter
mi	mile
POC	point of compliance
QA	quality assurance
QA/QC	quality assurance/quality control
QC	quality control
RAP	remedial action plan
RRM	residual radioactive material
SOP	standard operating procedure
TDS	total dissolved solids
UMTRA	Uranium Mill Tailings Remedial Action
UMTRCA	Uranium Mill Tailings Radiation Control Act
WSAP	water sampling and analysis plan
yd ³	cubic yard

1.0 INTRODUCTION

1.1 PURPOSE

This water sampling and analysis plan (WSAP) provides the regulatory and technical basis for ground water and surface water sampling at the Uranium Mill Tailings Remedial Action (UMTRA) Project processing site (GUN-01) and disposal site (GUN-08) near Gunnison, Colorado. It identifies and justifies the sampling locations, analytical parameters, and sampling frequencies. The ground water and surface water data are used to ensure protection of human health and the environment, for site characterization, and for compliance monitoring.

Ground water and surface water monitoring activities are based on the U.S. Environmental Protection Agency (EPA) regulations in 40 CFR Part 192 (1993) and the proposed EPA standards of 1987 (52 FR 36000 (1987)), UMTRA Project standard operating procedures (SOP) (JEG, n.d.), the *Technical Approach Document* (DOE, 1989), the *Guidance for Implementing the UMTRA Project Long-term Surveillance Program* (DOE, 1992b), and the most effective technical approach for the site.

This WSAP summarizes the results of previous water sampling activities and the plan for water sampling activities for calendar year 1994. A buffer zone monitoring plan is included as an appendix to this WSAP; this plan is designed to protect the public from residual contamination that entered the ground water as a result of the former milling operations.

1.2 SITE LOCATION

The Gunnison processing site is just south of the Gunnison, Colorado, city limits in Gunnison County (Figure 1.1). The site is in Sections 2 and 11, Township 49 North, Range 1 West. The entire site covers 61 acres (ac) (25 hectares [ha]) in the valley of the Gunnison River and Tomichi Creek. Contaminated materials at the Gunnison processing site include the tailings pile, which covers about 35 ac (14 ha). The tailings pile contains 459,000 cubic yards (yd³) (351,000 cubic meters [m³]); average depth is 9 feet (ft) (3 meters [m]). Site characterization activities have been conducted at and in the vicinity of the Gunnison processing site since 1983. The results of these investigations indicate that uranium processing activities have affected the ground water quality at and downgradient of the Gunnison processing site and that uranium is the major hazardous constituent of concern. The area of ground water monitoring extends southwest (downgradient) beyond the processing site boundary and includes selected locations along Goodwin Lane, Gold Basin Road, and in the Dos Rios subdivision (Units 2, 3, and the Island Unit) (Figure 1.2).

During surface remedial action construction, the contaminated materials will be disposed of and stabilized in a 29-ac (12-ha) engineered cell partially

FIGURE 1.1
LOCATION OF PROCESSING AND DISPOSAL SITES, GUNNISON, COLORADO

below grade, 6 miles (mi) (10 kilometers [km]) east of the processing site in Section 15, Township 49 North, Range 1 East (Figure 1.1). The Gunnison disposal cell is approximately 2000 ft (600 m) south of the Gunnison County landfill.

1.3 SITE HISTORY

Radioactive materials were processed at the former Gunnison mill site from 1958 to 1962. Ore processed at the mill came from Cochetopa mining district, about 25 mi (40 km) southeast of Gunnison. The Gunnison milling process extracted uranium oxide from the host rock by a complex chemical leaching and precipitation process. The ore was ground and then leached with sulfuric acid and sodium chlorate. After leaching, the uranium-rich solutions and waste solids were separated by a four-stage countercurrent classified and thickener circuit. The uranium solutions were then treated by solvent extraction to concentrate and recover the uranium; the solids were dumped in what became the tailings pile. During its 4 years of operation, the mill processed about 540,000 dry tons (490,000 metric tonnes) of ore with an average grade of about 0.15 percent uranium oxide (FBDU, 1981).

1.4 SITE STATUS

The following corrective actions are being conducted pursuant to the requirements of the Uranium Mill Tailings Radiation Control Act (UMTRCA) (42 USC §7901 *et seq.*) to satisfy the EPA standards in 40 CFR Part 192 (1993) for cleanup, stabilization, and control of the residual radioactive materials (RRM):

- Tailings are being relocated to an engineered disposal cell approximately 6 mi (10 km) east of the town of Gunnison and 0.4 mi (0.6 km) south of the Gunnison County landfill (Figure 1.1). The disposal cell will cover approximately 29 ac (12 ha). By the end of construction in 1993, approximately 20 percent of the total volume of 850,000 yd³ (650,000 m³) of contaminated materials were relocated in the disposal cell.
- An alternate supply of potable water is provided to private residents whose ground water has been significantly and adversely affected by the uranium processing activities.
- Water quality is monitored at selected locations at and downgradient of the former Gunnison processing site, including selected locations along Goodwin Lane, Gold Basin Road, and in the Dos Rios subdivision (Units 2, 3, and the Island Unit).

A ground water restoration alternative will be selected and implemented for the area affected by uranium processing activities.

1.5 SAMPLING PLAN

Water sampling is scheduled for March/April and October 1994 at the Gunnison processing and disposal sites for selected U.S. Department of Energy (DOE) monitor wells at both sites, private industrial and domestic wells downgradient of the processing site, and two ponds (one downgradient and the other crossgradient) of the processing site. Private domestic wells are being sampled for health-protection monitoring in and beyond areas where the contaminant plume has been detected. Details of domestic well sampling are provided in the appendix.

The monitor well locations provide a representative distribution of sampling points to characterize ground water quality and flow conditions in the vicinity of the sites. The list of analytes has been modified with time to reflect constituents that are related to uranium processing activities, based on information in the *Baseline Risk Assessment of Ground Water Contamination at the Uranium Mill Tailings Site Near Gunnison, Colorado* (DOE, 1994a), and the remedial action plan (RAP) (DOE, 1992a). Chemical constituents needed for geochemical evaluation are also analyzed. Water sampling will be conducted semiannually during and one year following the period of construction activities, at a minimum.

2.0 GUNNISON PROCESSING SITE

2.1 SITE CONCEPTUAL MODEL

The site conceptual model is based on available hydrogeologic information, site reconnaissance, and data from monitor wells installed in the alluvium; the alluvium consists of recent floodplain and terrace deposits associated with the Gunnison River and Tomichi Creek (Figure 2.1 and Table 2.1). The site conceptual model is summarized below.

2.1.1 Physiographic setting

Gunnison, Colorado, is the focal point of four valleys and is surrounded by mountain peaks rising to over 12,000 ft (3700 m). The site (GUN-01) is in a valley formed by the Gunnison River. The valley is surrounded by the Gunnison National Forest on the north, east, and south and it is about 20 mi (32 km) west of the Continental Divide of the Rocky Mountains. The elevation of the site is approximately 7640 ft (2330 m) above mean sea level. The soil in the low hills surrounding the valley is largely a gravel-based mixture (FBDU, 1981). Many creeks that flow into the Gunnison River near the site begin in these mountains. Tomichi Creek enters the Gunnison River southwest of the site. The Gunnison River flows into Blue Mesa Reservoir approximately 5 mi (8 km) southwest of the site, at an approximate elevation of 7520 ft (2290 m). This elevation is more than 100 ft (30 m) lower than the elevation at the processing site.

2.1.2 Geology

Widespread recent floodplain and terrace deposits (hereafter referred to as alluvium) that are associated with the Gunnison River and Tomichi Creek underlie the Gunnison processing site and surrounding vicinity. The alluvium is composed of poorly sorted material ranging from fine-grained clay to coarse-grained gravels and cobbles with occasional boulders. Figure 2.2 provides a geologic cross sectional view of the subsurface materials. The thickness of the alluvium is extensive, ranging from 72 ft (22 m) to greater than 130 ft (40 m). The alluvium extends below most of the DOE boreholes and wells. However, four DOE monitor wells outside the designated processing site boundary encountered shale from the Morrison Formation or Precambrian bedrock at depths ranging from 72 to 130 ft (22 to 40 m) (DOE, 1992a). A discontinuous unit of unknown extent and thickness, known as the Brushy Basin Member of the Morrison Formation, underlies the alluvium. The Brushy Basin Member is an erosional remnant. Because the Brushy Basin Member is not a significant water-bearing formation, it is not discussed further in this document.

FIGURE 2.1
WATER QUALITY SAMPLING LOCATIONS IN THE VICINITY OF THE PROCESSING SITE
GUNNISON, COLORADO

Table 2.1 DOE monitor well information for the Gunnison UMTRA Project Processing site, Gunnison, Colorado

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	GROUND ELEVATION (FT MSL)	BOREHOLE DEPTH (FT)	BOREHOLE DIAMETER (INCHES)	CASING ELEVATION (FT MSL)	CASING DEPTH (FT)	CASING DIAMETER (INCHES)	SCREEN BEGINNING DEPTH (FT)	SCREEN LENGTH (FT)	FLOW CODE	FORMATION OF COMPLETION
0001	3528.9	2399.5	7653.87	18.10	6.875	7655.81	20.05	2.000	8.00	5.0	U	AL
0002	2453.0	2399.1	7647.16	20.20	6.875	7649.20	22.20	2.000	10.00	5.0	U	AL
0003	2799.8	1063.3	7647.62	18.00	6.875	7649.64	20.85	2.000	10.00	5.0	C	AL
0004	2448.9	1765.1	7662.42	40.65	12.875	7664.41	42.65	2.000	30.00	5.0	O	AL
0005	2149.0	1126.0	7644.15	18.70	6.875	7645.78	20.30	2.000	10.00	5.0	D	AL
0006	1633.8	1639.6	7645.09	20.00	6.875	7647.07	21.98	2.000	10.00	5.0	D	AL
0007	1591.9	1868.8	7644.20	21.00	6.875	7646.21	22.95	2.000	11.00	5.0	D	AL
0008	1539.1	1872.3	7643.92	50.20	12.875	7645.41	51.68	8.000	30.00	17.9	D	AL
0009	1435.0	1816.5	7643.22	20.10	6.875	7645.24	22.12	2.000	10.00	5.0	D	AL
0010	1421.9	1453.7	7643.95	17.90	6.875	7645.90	19.82	2.000	8.00	5.0	D	AL
0011	1428.6	1187.5	7642.65	20.30	6.875	7644.45	22.14	2.000	10.00	5.0	D	AL
0012	1193.7	1738.3	7643.22	19.10	6.875	7645.35	21.23	2.000	10.00	5.0	D	AL
0013	912.6	997.6	7641.67	21.00	6.875	7643.70	23.05	2.000	11.00	5.0	D	AL
0014	755.9	1616.9	7642.11	19.90	6.875	7644.07	21.90	2.000	10.00	5.0	D	AL
0101	3523.6	2399.5	7653.74	49.60	6.875	7655.61	53.50	2.000	41.50	5.0	U	AL
0102	2453.4	2405.6	7647.22	52.00	6.875	7649.18	54.00	2.000	42.00	5.0	U	AL
0103	2800.9	1056.5	7647.69	50.00	6.875	7649.53	51.80	2.000	40.00	5.0	C	AL
0104	2459.8	1765.8	7662.48	70.00	12.875	7664.49	72.00	2.000	60.00	5.0	O	AL
0105	2148.1	1130.1	7644.12	52.10	6.875	7645.99	54.00	2.000	42.00	5.0	D	AL
0106	1634.0	1634.2	7645.14	44.30	6.875	7647.18	46.37	2.000	34.00	5.0	D	AL
0107	1591.5	1873.3	7644.19	53.00	6.875	7646.25	55.05	2.000	43.00	5.0	D	AL
0109	1437.0	1811.0	7643.20	53.50	6.875	7644.96	55.30	2.000	45.00	5.0	D	AL
0110	1421.7	1459.8	7644.02	48.90	6.875	7645.81	50.58	2.000	38.50	5.0	D	AL
0111	1430.8	1179.4	7642.60	52.10	6.875	7644.52	54.05	2.000	42.00	5.0	D	AL
0112	1192.5	1733.2	7643.15	49.70	6.875	7644.80	51.35	2.000	40.00	5.0	D	AL
0113	991.8	1003.3	7641.79	51.30	6.875	7643.77	53.25	2.000	41.00	5.0	D	AL
0120	1480.5	-193.0	7634.96	41.00	6.000	7636.50	27.00	2.000	20.00	5.0	D	AL
0121	1459.3	-180.9	7634.76	102.50	6.000	7636.44	102.00	2.000	95.00	5.0	D	AL
0122	1457.7	-187.8	7634.68	100.00	6.000	7636.60	87.00	2.000	80.00	5.0	D	AL
0123	1473.5	-209.4	7634.92	61.00	6.000	7636.68	62.00	2.000	55.00	5.0	D	AL
0125	131.0	-153.3	7630.84	24.80	6.000	7632.57	27.50	2.000	20.50	5.0	D	AL
0126	121.3	-165.3	7631.02	61.00	6.000	7632.82	62.00	2.000	55.00	5.0	D	AL
0127	112.1	-174.5	7630.97	101.00	6.000	7632.91	103.20	2.000	96.20	5.0	D	AL
0130	433.0	1400.5	7639.63	26.00	6.000	7641.48	27.00	2.000	20.00	5.0	D	AL
0132	433.7	1421.6	7639.74	100.50	6.000	7641.57	102.50	2.000	95.50	5.0	D	AL
0133	1641.0	1697.4	7639.72	21.00	6.000	7641.70	19.00	2.000	12.00	5.0	D	AL
0134	1634.4	1690.9	7639.59	21.00	6.000	7641.94	19.00	2.000	12.00	5.0	D	AL
0135	-743.6	-1457.6	7624.44	25.00	6.000	7626.17	27.00	2.000	18.00	5.0	D	AL
0136	-744.1	-1448.5	7624.51	61.00	6.000	7626.28	62.00	2.000	55.00	5.0	D	AL
0137	-745.5	-1437.7	7624.59	105.00	6.000	7626.11	102.00	2.000	95.00	5.0	D	AL

Table 2.1 DOE monitor well information for the Gunnison UMTRA Project Processing site, Gunnison, Colorado (Concluded)

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	GROUND ELEVATION (FT MSL)	BOREHOLE DEPTH (FT)	BOREHOLE DIAMETER (INCHES)	CASING ELEVATION (FT MSL)	CASING DEPTH (FT)	CASING DIAMETER (INCHES)	SCREEN BEGINNING DEPTH (FT)	SCREEN LENGTH (FT)	FLOW CODE	FORMATION OF COMPLETION
0140	392.9	2723.0	7640.79	26.00	6.000	7642.81	27.00	2.000	20.00	5.0	U	AL
0141	379.0	2722.6	7640.75	60.00	6.000	7642.85	62.00	2.000	57.00	5.0	U	AL
0142	364.3	2722.4	7640.63	98.50	6.000	7642.43	100.50	2.000	93.50	5.0	U	AL
0145	-1146.3	653.5	7630.76	27.00	6.000	7632.53	27.00	2.000	20.00	5.0	D	AL
0147	-1132.8	637.5	7631.10	101.00	6.000	7632.76	102.00	2.000	95.00	5.0	D	AL
0155	-2676.0	-1381.2	7618.87	27.00	6.000	7620.70	27.00	2.000	20.00	5.0	D	AL
0157	-2668.8	-1402.9	7618.84	101.00	6.000	7620.55	99.00	2.000	92.00	5.0	D	AL
0160	-1792.0	-5280.3	7597.52	75.00	6.000	7599.12	60.00	2.000	53.00	5.0	D	AL
0161	-1803.3	-5286.9	7597.35	101.00	6.000	7599.11	102.00	2.000	95.00	5.0	D	AL
0163	-38.7	-5678.2	7604.50	61.00	6.000	7606.62	63.00	2.000	56.00	5.0	C	AL
0170	872.1	1009.5	7640.58	141.00	6.000	7642.26	143.00	2.000	111.00	5.0	D	AL
0178	-	-	-	-	-	-	-	-	-	-	U	AL
0179	-	-	-	-	-	-	-	-	-	-	U	AL
0181	-1357.9	-2639.7	7615.31	28.00	6.000	7617.40	27.00	2.000	20.00	5.0	D	AL
0183	-1344.4	-2652.6	7615.25	101.00	6.000	7617.32	102.00	2.000	95.00	5.0	D	AL
0184	-1818.1	-4210.4	7606.88	61.00	6.000	7608.76	62.00	2.000	55.00	5.0	D	AL
0185	-1825.7	-4208.5	7606.95	101.00	6.000	7608.87	102.00	2.000	95.00	5.0	J	AL
0186	-67.3	-1798.4	7624.26	61.00	6.000	7626.01	62.00	2.000	55.00	5.0	D	AL
0187	-68.7	-1791.2	7624.39	101.00	6.000	7625.76	102.00	2.000	95.00	5.0	D	AL
0188	-978.6	-4343.5	7612.07	61.00	6.000	7613.67	62.00	2.000	55.00	5.0	D	AL
0189	-987.5	-4346.9	7612.37	100.00	6.000	7613.75	102.00	2.000	95.00	5.0	D	AL
0191	3100.0	1770.0	-	-	-	7642.85	-	-	-	-	O	AL
0192	2090.0	1850.0	7661.8	-	-	7642.43	-	-	-	-	O	AL
0194	1894.6	-1445.3	7634.43	94.00	6.000	7636.26	85.00	2.000	87.00	5.0	D	AL
0195	1883.0	-1450.9	7634.22	60.00	6.000	7636.41	62.00	2.000	51.00	5.0	D	AL
0196	361.7	-3542.0	7618.62	60.00	6.000	7620.53	62.00	2.000	53.00	5.0	D	AL
0197	354.6	-3554.1	7618.82	100.00	6.000	7620.58	102.00	2.000	93.00	5.0	D	AL
0198	-	-	-	-	-	-	-	-	-	-	D	AL

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM

FLOW RELATIONSHIP CODE:
U - UPGRADIENT
D - DOWN GRADIENT
C - CROSS GRADIENT
O - ON-SITE

DATA FILE: M:\DART\GUN01\MMI10007.DAT

FIELDS DISPLAYED WITH A DASH INDICATE THE DATA IS UNAVAILABLE

FIGURE 2.2
GEOLOGIC CROSS SECTION (NORTHEAST-SOUTHWEST) OF THE PROCESSING SITE VICINITY,
GUNNISON, COLORADO

2.1.3 Hydrology

The uppermost aquifer occurs within the alluvium at and within the vicinity of the processing site. During previous site characterization activities, the DOE placed monitor well clusters on the site, upgradient, and downgradient of the Gunnison mill tailings. These monitor well clusters generally consist of a shallow well (approximately 10 to 25 ft [3 to 8 m] below land surface), an intermediate well (approximately 40 to 60 ft [12 to 18 m] below land surface), and a deep well (approximately 90 to 100 ft [27 to 30 m] below land surface). The bottom 5 ft (2 m) of each well is screened.

Depths to the water table range from 0.2 ft (0.06 m) to 14 ft (4 m) and average 5 ft (2 m). Static water level elevations measured in the intermediate monitor wells are displayed in Figure 2.3. This water table contour map shows the alluvial ground water flows southwest as a subdued topographic replica of the land surface. The direction of horizontal ground water movement is comparable in the shallow and deep monitor wells. The alluvial aquifer is generally unconfined. However, noncontinuous layers of low hydraulic conductivity silt and clay may create semiconfined conditions with increasing depth in the alluvium. Static water levels in each well monitor well cluster generally indicate a downward vertical gradient. However, because ground water elevations in the alluvium fluctuate seasonally at the site, these downward vertical gradients may reverse locally in accordance with changes in recharge and discharge. The seasonal high water table usually occurs in early summer and the seasonal low water table usually occurs in late winter (DOE, 1994a).

The alluvial aquifer is recharged from upgradient underflow, precipitation, snowmelt, and seasonally from the Gunnison River and Tomichi Creek. In addition, seasonal recharge occurs from the irrigation ditches around the site. Ground water discharge is expected to occur as a result of localized pumping, shallow baseflow to the Gunnison River and/or Tomichi Creek, and deep ground water underflow that follows the southwest course of the Gunnison River toward Blue Mesa Reservoir downgradient of the Dos Rios subdivision.

Hydraulic properties at the Gunnison processing site are estimated in the RAP (DOE, 1992a). Hydraulic conductivities range from 10 to 240 feet per day (ft/day) (0.0035 to 0.085 centimeters per second [cm/s]). The wide range in hydraulic conductivity values results from the variation in size of the poorly sorted subsurface material, from clay to gravels and cobbles with occasional boulders. The calculated horizontal hydraulic gradient ranges from 0.0038 to 0.0048 (DOE, 1992a). Linear ground water velocities were calculated by applying Darcy's Law using the calculated range of hydraulic conductivities (10 to 240 ft/day [0.0035 to 0.085 cm/s]), horizontal water table gradients (0.0038 to 0.0048), and the assumed porosity value (0.25 for gravelly alluvium) appropriate for the site (Freeze and Cherry, 1979; Davis and DeWeist, 1966). From this calculation, ground water velocities in the alluvial aquifer are estimated to range from 56 to 1700 feet/year (ft/yr) (1.1×10^{-4} to 33×10^{-4} cm/s), and average approximately 270 ft/yr (2.6×10^{-4} cm/s) (DOE, 1992a).

FIGURE 2.3
WATER TABLE CONTOUR MAP FOR THE ALLUVIAL AQUIFER (INTERMEDIATE WELLS)
AT THE PROCESSING SITE, GUNNISON, COLORADO

Although ground water velocity is subject to localized variations from heterogeneities in the subsurface materials, the calculated average value appears to be representative of the alluvial ground water system, based on the distance of contaminant plume migration relative to the time the tailings have been on the site. Assuming ground water moves at an approximate rate of 270 ft/yr (2.6×10^{-4} cm/s), when the tailings have been in place at the processing site for approximately 30 years the leading edge of residual contamination from uranium milling activities can be expected to be roughly 8100 ft (2500 m) downgradient from the tailings pile. Based on actual water quality data for conservative (mobile) species (uranium and sulfate), the estimated ground water velocity value appears to be representative.

2.1.4 Water quality

Water quality sampling has been conducted at the Gunnison processing site since 1983. Constituents listed in Table 2.2 were analyzed during the screening monitoring to determine background and baseline ground water quality in the alluvium (DOE, 1989). This list was modified during subsequent sampling events to focus on the following hazardous constituents related to uranium processing activities: arsenic, cadmium, cobalt, gross alpha, iron, lead-210, manganese, polonium-210, radium-226 and -228, thorium-230, and uranium. Additional constituents also were analyzed for geochemical characterization: calcium, chloride, magnesium, potassium, sodium, sulfate, and total dissolved solids (TDS).

Background ground water quality is defined as the quality of ground water that would be expected at the site if uranium processing had not occurred (DOE, 1989). Alluvial background ground water quality at the processing site is characterized by TDS ranging from 196 to 428 milligrams per liter (mg/L), sulfate concentrations ranging from 11 to 38 mg/L, and alkalinity concentrations (expressed as calcium carbonate [CaCO_3]) ranging from 130 to 300 mg/L (DOE, 1994a). Uranium is present at low levels in all the background ground water samples, with a maximum observed value of 0.0085 mg/L.

Baseline ground water quality is defined as the representative water quality in a monitor well that has been influenced by uranium processing activities (DOE, 1989). Ground water at the Gunnison processing site is contaminated by acidic tailings leachate containing high concentrations of uranium, iron, manganese, and sulfate (DOE, 1994a). As discussed above, the background ground water at this site contains relatively low sulfate and uranium concentrations. Conversely, these constituents are present at relatively high levels in tailings effluent.

Once introduced to the alkaline ground water typical of the Gunnison processing site, uranium and sulfate behave chemically as relatively conservative (mobile) components (DOE, 1994a). Uranium and sulfate are excellent tracers of the extent of contamination and plume geometry at this site. Although the highest uranium and sulfate concentrations are found in ground water adjacent to the

Table 2.2 Analytical constituents measured for baseline water quality screening

Constituent	MCL ^a	Constituents without MCLs	
Arsenic ^b	0.05	Aluminum	Magnesium ^c
Barium	1.0	Ammonium	Manganese ^b
Cadmium ^b	0.01	Antimony ^b	Nickel ^b
Chromium ^b	0.05	Beryllium ^b	Phosphate
Lead ^b	0.05	Boron	Potassium ^c
Mercury	0.002	Bromide	Silica
Molybdenum ^b	0.1	Calcium ^c	Sodium ^c
Nitrate ^b	44.0	Chloride ^c	Strontium
Selenium ^b	0.01	Cobalt ^b	Sulfate ^{b,c}
Silver	0.05	Copper ^b	Sulfide
Combined radium ^b -226 and -228	5.0 ^d	Cyanide	Thallium ^b
Combined uranium ^b -234 and -238	30.0 ^d	Fluoride	Tin ^b
Net gross alpha ^b (excluding radon and uranium)	15.0 ^d	Iron ^b	Vanadium ^b
		Total Kjeldahl nitrogen	Zinc ^b
		Total dissolved solids ^c	Total organic carbon
		Polonium-210 ^b	Lead-210 ^b
			Thorium-230 ^b

^aMaximum concentration limits (MCL) expressed in milligrams per liter unless otherwise noted.

^bPotential hazardous constituent related to uranium processing activities.

^cGeochemical characterization.

^dPicocuries per liter (pCi/L).

Ref: DOE, 1989.

tailings pile, concentrations of these constituents that are above background levels are present in ground water approximately 8100 ft (2500 m) downgradient from the tailings pile (Figures 2.4 and 2.5) (data for intermediate wells screened approximately 40 to 60 ft [12 to 18 m] below land surface). The geometry and movement of the uranium plume (Figure 2.4) mirrors that of the sulfate plume (Figure 2.5). The trends of uranium and sulfate over the past 4 years are shown in their respective time versus concentration plots (Figures 2.6 and 2.7). These graphs show ground water quality trends for uranium and sulfate for a background monitor well (102), a monitor well in the contaminant plume (186), and a downgradient monitor well (160) that appears to be encroached by the leading edge of the contaminant plume. Uranium concentrations range from 0.003 to 0.005 mg/L in monitor well 102, increase by an order of magnitude in plume well 186, and are slightly elevated above background in downgradient monitor well 160. Sulfate concentrations show a similar trend, with background concentrations ranging from 22 to 33 mg/L in background, increasing to 410 to 490 mg/L in the plume, and decreasing to 80 to 140 mg/L at the edge of the plume.

Shallow ground water across the river (0 to 30 ft [9 m]) has not been tested by DOE monitor wells and contamination is not expected. Most domestic wells in the Dos Rios subdivision are drilled in the shallow zone, at depths of 20 to 30 ft (6 to 9 m). Although domestic wells east of the Gunnison River have shown contamination, domestic wells west of the Gunnison River and in the Island Unit have not shown elevated contamination levels (DOE, 1994a).

The Gunnison baseline risk assessment identifies nine contaminants of potential concern (DOE, 1994a): cadmium, cobalt, iron, lead-210, manganese, polonium-210, sulfate, thorium-230, and uranium. The mean ground water concentrations for five of these constituents exceed the protective criteria or guidelines cited in the baseline risk assessment for humans, aquatic life, livestock, and/or irrigation: iron, manganese, sulfate, lead-210, and uranium. The potential effects of these constituents are detailed in the baseline risk assessment (DOE, 1994a).

Contaminated alluvial ground water is believed to discharge in part to the Gunnison River. However, available surface water and sediment data from the water bodies in the site vicinity suggest that contaminated ground water from the site has not adversely affected the surface water and sediment quality in the vicinity of the Gunnison UMTRA Project site (DOE, 1994a).

2.2 DATA COLLECTION OBJECTIVES

Data collection objectives (DCO) identify the reasons for collecting data, which include regulatory requirements, compliance monitoring, site characterization, risk assessment.

Data quality objectives (DQO) define the manner in which samples are collected, handled, and analyzed. DQOs define analytical support levels; follow standard

LEGEND

- 126 ○ DOE MONITOR WELL
- 0.031 URANIUM CONCENTRATION (mg/L)
- 0.100 — URANIUM ISOPLETH (mg/L)
(DASHED WHERE INFERRED)
- 50 U.S. HIGHWAY
- 500 0 500 1000 FEET
- 150 0 150 300 METERS

FIGURE 2.4
URANIUM CONCENTRATIONS IN ALLUVIAL GROUND WATER (INTERMEDIATE WELLS)
AT THE PROCESSING SITE, GUNNISON, COLORADO

FIGURE 2.5
SULFATE CONCENTRATIONS IN ALLUVIAL GROUND WATER (INTERMEDIATE WELLS)
AT THE PROCESSING SITE, GUNNISON, COLORADO

LEGEND

—	186	PLUME MONITOR WELL
- - -	160	DOWNGRADIENT MONITOR WELL
—	102	BACKGROUND MONITOR WELL

FIGURE 2.6
URANIUM CONCENTRATIONS VERSUS TIME IN SELECTED BACKGROUND, PLUME, AND DOWNGRADIENT MONITOR WELLS AT THE PROCESSING SITE GUNNISON, COLORADO

LEGEND

- 186 PLUME MONITOR WELL
- - - 160 DOWNGRAIDENT MONITOR WELL
- 102 BACKGROUND MONITOR WELL

FIGURE 2.7
SULFATE CONCENTRATIONS VERSUS TIME IN SELECTED BACKGROUND, PLUME, AND DOWNGRAIDENT MONITOR WELLS AT THE PROCESSING SITE GUNNISON, COLORADO

procedures for water sampling, preservation, transport, and various other field procedures; ensure procedures follow quality assurance (QA) and quality control (QC) protocols; and provide analytical data validation. DQOs to be followed during data collection and evaluation activities are stated in the WSAP guidance document (DOE, 1993) and applicable SOPs (JEG, n.d.).

2.2.1 Regulatory requirements

The regulatory requirements for ground water and surface water sampling at the Gunnison processing site are specified in 40 CFR Part 192 (1993).

2.2.2 Compliance monitoring

Surface remedial action started in 1992 and is scheduled for completion in 1995. Ground water compliance monitoring is required during construction (DOE, 1992a).

2.2.3 Site characterization

Previous characterization activities and the baseline risk assessment (DOE, 1994a) indicate the uranium plume extends approximately 8100 ft (2500 m) to the southwest (downgradient) of the processing site. Concentrations of uranium above background levels were detected in shallow, intermediate, and deep monitoring wells at sampling points throughout the lateral extent of the plume. DOE monitor well clusters will be sampled to determine the extent and potential movement of the plume. Construction information for the monitor well clusters is discussed in Section 2.1.3 and in Table 2.1.

2.2.4 Risk assessment

Future ground water monitoring of private domestic wells is advisable in some areas of the Dos Rios subdivision for the following reasons (DOE, 1994a):

- Although the DOE has already provided an alternate water supply system, a so-called buffer zone of representative domestic wells in Unit 2 of the Dos Rios subdivision will be monitored. The buffer zone is downgradient from the area currently covered by the water distribution system.
- The water distribution system is connected to households for potable water consumption and washing. Water needed for outside use may be drawn from private irrigation wells. Ground water drawn from these irrigation wells should be monitored to provide assurance that the water quality remains suitable for irrigation and livestock watering.

Additional information is provided in the appendix to this document ("Buffer Zone Monitoring Plan for the Dos Rios Subdivision, Gunnison, Colorado"). As additional water quality and water level data are collected and interpreted, the WSAP will be updated annually to provide ongoing monitoring to protect public

health and the environment. Ground water monitoring shall not continue after the ground water is determined to be in compliance with the ground water cleanup standards promulgated under UMTRCA. Ground water monitoring in the Dos Rios subdivision will be terminated in consultation with the Colorado Department of Health (CDH), as discussed in Section 2.3.6.

2.3 WATER SAMPLING PLAN

Water quality sampling is conducted at the processing site to 1) ensure protection of human health and the environment, 2) monitor ground water compliance during remedial action construction, and 3) define the extent of contamination. Sampling locations, constituent selection, and sampling frequency are discussed in Sections 2.3.1 to 2.3.3, respectively. Interpretation and evaluation of analytical data are discussed in Sections 2.3.4 and 2.3.5. WSAP modifications and termination of monitoring are discussed in Section 2.3.6.

2.3.1 Sampling locations

Ground water will be sampled both at the DOE monitor wells and the private wells at and in the vicinity of the Gunnison processing site. A total of 29 DOE monitor wells will be sampled at the locations shown in Figure 2.1. Table 2.3 provides the rationale for recommended sampling locations and the order of sample collection (based on historical information regarding lowest to highest concentrations of hazardous constituents) for the DOE monitor well clusters. Samples collected from DOE monitor wells are filtered in the field. When only a limited quantity of water is available, sample collection bottles are prioritized (from highest priority to lowest) as follows: metals, anions, gross alpha, radium-226, radium-228, lead-210, thorium-230, polonium-210. This order attains the maximum number of analytes using the least quantity of water during sample collection.

A total of 13 private wells will be sampled in the former processing site vicinity. A description and rationale for sampling private wells are provided in Table 2.4. Irrigation wells within the Dos Rios subdivision (Unit 3) and buffer zone wells beyond the current extent of the plume (Unit 2) will be monitored. If a buffer zone well on the west side of the Gunnison River is not accessible, an alternate private well will be sampled (Table 2.4). Samples from private wells will be collected from a water outlet downstream of any private filtering system. Unfiltered samples will be collected from the domestic wells.

Two surface water samples will be collected in the vicinity of the former processing site: one from the campground pond and the other from the pond by the gravel pit (Figure 2.1). Surface water sampling rationales are provided in Table 2.5. These two locations will be monitored during surface remedial action construction, at a minimum. Filtered and unfiltered surface water samples will be collected.

Table 2.3 DOE monitor well sampling locations for the Gunnison UMTRA Project processing site and vicinity

Well ID	Location	Screened interval (ft bls)	Sampling rationale
GUN-01-0001*	Background	8.0 - 13.0	Characterize background water quality before, during, and after tailings removal.
GUN-01-0101*	Background	41.5 - 46.5	
GUN-01-0002	Background	10.0 - 15.0	
GUN-01-0102	Background	42.0 - 47.0	
GUN-01-0163*	Crossgradient	56.0 - 61.0	Delineate the horizontal and vertical extent of the plume. Monitor concentration trends. Locations may be modified following completion of surface remedial action construction activities.
GUN-01-0120	Downgradient	20.0 - 25.0	
GUN-01-0121	Downgradient	95.0 - 100.0	
GUN-01-0123	Downgradient	55.0 - 60.0	
GUN-01-0136	Downgradient	55.0 - 60.0	
GUN-01-0145	Downgradient	20.0 - 25.0	
GUN-01-0147	Downgradient	95.0 - 100.0	
GUN-01-0196	Downgradient	53.0 - 58.0	Beyond the current plume, so these wells can be used to detect horizontal and vertical plume migration in the buffer zone monitoring area (Dos Rios subdivision, Unit 2). Provide data quality control through proper monitor well construction, discrete interval sampling, lithologic log data, and a historical water quality data base. Locations may be modified following completion of surface remedial action construction activities.
GUN-01-0197	Downgradient	93.0 - 98.0	
GUN-01-0160*	Downgradient	53.0 - 58.0	
GUN-01-0161*	Downgradient	95.0 - 100.0	
GUN-01-0125	Downgradient	20.5 - 25.5	Downgradient monitor wells within current plume will be used to track plume migration. Provide data QC through proper monitor well construction, discrete interval sampling, lithologic log data, and a historical water quality data base. Locations may be modified following completion of surface remedial action construction activities.
GUN-01-0126	Downgradient	55.0 - 60.0	
GUN-01-0127	Downgradient	96.2 - 101.2	
GUN-01-0130	Downgradient	20.0 - 25.0	
GUN-01-0132	Downgradient	95.5 - 100.5	
GUN-01-0188*	Downgradient	55.0 - 60.0	
GUN-01-0189*	Downgradient	95.0 - 100.0	
GUN-01-0186*	Downgradient	55.0 - 60.0	
GUN-01-0181	Downgradient	20.0 - 25.0	
GUN-01-0183	Downgradient	95.0 - 100.0	

**Table 2.3 DOE monitor well sampling locations for the Gunnison UMTRA Project processing site and vicinity¹
(Concluded)**

Well ID	Location	Screened interval (ft bls)	Sampling rationale
GUN-01-0006	On-site	10.0 - 15.0	Characterize on-site water quality before and during tailings removal. Locations may be modified following the completion of construction activities.
GUN-01-0106	On-site	34.0 - 39.0	
GUN-01-0013	On-site	11.0 - 16.0	
GUN-01-0113	On-site	41.0 - 46.0	

*Field measurements Fe^{2+} and S at DOE monitor well clusters.

Note: Prioritized from cleanest samples to most contaminated.
bls—below land surface.

Table 2.4 Private well sampling locations downgradient from the Gunnison processing site

Well ID	Description	Sampling rationale
GUN-01-0461	Private batch plant well	Indicates plume migration during seasonal gravel pit dewatering operations. Monitored during surface remediation activities, at a minimum.
GUN-01-0454 GUN-01-0455 GUN-01-0468 GUN-01-0474 GUN-01-0600 GUN-01-0601	Domestic irrigation wells adversely affected by the uranium plume.	Ensures continued safety of these wells for irrigation and livestock uses.
GUN-01-0469 GUN-01-0661 GUN-01-0665 GUN-01-0667 GUN-01-0680 GUN-01-0683	Domestic buffer zone wells in Unit 2 of the Dos Rios subdivision not affected by the uranium plume and downgradient from the area currently covered by the water distribution system.	The DOE is committed to monitoring a buffer zone of domestic wells to ensure that the characteristics of the uranium plume do not change and adversely affect wells in this area.
GUN-01-0660 GUN-01-0679 GUN-01-0684 GUN-01-0685 GUN-01-0686 GUN-01-0687	Alternate domestic wells in Unit 2 of the Dos Rios subdivision not affected by the uranium plume and downgradient from the area currently covered by the water distribution system.	One (or more) of these alternate wells will be sampled only if one (or more) of the primary six buffer zone residents (listed in the row above) are not home. Alternate sampling locations have been selected so that six buffer zone wells will be monitored semiannually and so the geographic distribution of buffer zone sampling locations is consistent with that of the primary buffer zone locations (i.e., if a primary location is not accessible, a neighboring location will be sampled as an alternate).

Table 2.5 Surface water sampling locations in the vicinity of the Gunnison processing site

Surface water location ID	Description	Sampling rationale
GUN-01-0779	Campground pond	Monitor water quality to ensure the human health and the environment are not at risk.
GUN-01-0780	Northeast corner of the gravel pit dewatering pond	Elevated concentrations of hazardous constituents have been detected during seasonal dewatering operations. These constituents may be derived from the tailings pile. Coupled with samples collected from a nearby batch plant well, this surface water sample provides useful plume tracking information.

2.3.2 Constituent selection

The ground water monitoring program includes collecting and analyzing ground water samples from the monitor wells listed in Tables 2.3 and 2.4, and discussed in Section 2.3.1. Ground water samples initially were evaluated for hazardous constituents generally expected to be in or derived from the RRM related to the uranium processing activities. Constituents analyzed during the screening monitoring to determine background and baseline ground water quality included those listed in Table 2.2 and discussed in Section 2.1.4. The list of constituents was modified during subsequent sampling events to reflect hazardous constituents related to uranium processing activities at this site.

Based on existing ground water quality data and the results of the baseline risk assessment (DOE, 1994a), the following constituents will be monitored at DOE monitor wells in 1994 at the Gunnison processing site:

- Field parameters: alkalinity, dissolved oxygen, oxidation/reduction potential, pH, specific conductivity, and temperature. In addition, ferrous iron and sulfide will be measured in the field at the DOE monitor well clusters specified in Table 2.3.
- Laboratory analyses: arsenic, cadmium, calcium, chloride, cobalt, gross alpha, iron, lead-210, magnesium, manganese, polonium-210, potassium, radium-226 and -228, sodium, sulfate, TDS, thorium-230, and uranium.

Cadmium, cobalt, iron, lead-210, manganese, polonium-210, sulfate, thorium-230, and uranium are potential hazardous constituents of concern (see Section 2.1.4). Additional constituents monitored for hydrogeochemical site characterization include calcium, chloride, magnesium, potassium, sodium, and TDS. As a result of the findings of the baseline risk assessment (DOE, 1994a),

several hazardous constituents (arsenic, radium-226 and radium-228, and gross alpha) were eliminated as potential risks and will not be monitored in October 1994.

Samples collected from downgradient private domestic or industrial wells (described in Sections 2.2.4 and 2.3.1 as irrigation wells or buffer zone wells) will be analyzed for the following constituents:

- Field parameters: alkalinity, dissolved oxygen, oxidation/reduction potential, pH, specific conductivity, and temperature.
- Laboratory analyses: uranium will be analyzed in samples collected from selected private domestic wells. One private irrigation well (GUN-01-0600) will be monitored annually (in the spring) for the suite of analytes listed for the DOE monitor wells and semiannually (in the fall) for uranium and field parameters listed above.

The DOE monitor well clusters provide sufficient coverage to monitor water quality trends. However, if there is a notable change in water quality in either irrigation well GUN-01-0600 or in the DOE monitor well clusters, additional parameters in the domestic irrigation wells and buffer zone wells will be considered.

Filtered and unfiltered surface water samples in the campground and gravel pit ponds are analyzed for the following constituents:

- Field parameters: alkalinity, pH, specific conductivity, and temperature.
- Laboratory analyses: calcium, iron, magnesium, manganese, sodium, sulfate, TDS, uranium, and zinc.

2.3.3 Sampling frequency

Ground water has been monitored at the Gunnison processing site since 1983 to establish background and baseline ground water quality prior to and during remedial action activities. Sampling to date allowed detection of seasonal variation in ground water quality. The sampling frequency permits evaluation of trends in ground water flow conditions and quality. It also provides additional information and continuity to the data base that will be useful during the project's ground water remediation phase.

The duration of the ground water monitoring program and the sampling schedule are determined by taking into account variations in historical background water quality measurements, the geochemistry of the source term (tailings pore fluid solution), the ground water flow rate, the possibility of seasonal variations in ground water quality, and the risk to human health and the environment.

Water quality sampling will be conducted semiannually during and 1 year following completion of surface remediation (through 1996), at a minimum. Sampling frequency then will be determined using updated water quality and hydrologic data obtained during surface remedial action and the ground water characterization program; information obtained from the *Gunnison, Colorado, Subpile Study Report* (DOE, 1994b); and the site baseline risk assessment (DOE, 1994a). The sampling frequency after surface remedial action and during ground water restoration will depend upon future site characterization efforts and the ground water restoration alternatives selected. Sampling frequency and the duration of ground water monitoring will be based on contaminant transport travel times and will account for a time lag after surface remedial action is complete. Based on the current hydrogeologic information available for the Gunnison site, the linear ground water velocity ranges from 56 to 1700 ft/yr (1.1×10^{-4} to 33×10^{-4} cm/s), and averages 270 ft/yr (2.6×10^{-4} cm/s), as discussed in Section 2.1.3. The travel time estimate is expected to be refined further during the ground water restoration phase of the UMTRA Project.

2.3.4 Data Interpretation

Water sampling data collected during 1994 will be analyzed and evaluated according to prescribed UMTRA Project procedures and compared with the existing data base. Trends will be analyzed to detect variations in ground water flow conditions and ground water quality. Variations will be evaluated and modifications to the sampling plan will be noted, justified, and implemented, as appropriate.

Long-term sampling frequencies and parameters will be determined, based on the following factors:

- Trends in uranium concentrations over time—Was an elevation in concentration a one-time occurrence or part of a statistical trend?
- Spatial changes in uranium concentrations—Does the plume appear to be spreading horizontally or with depth? How does any apparent plume migration compare with estimated contaminant transport travel times (based on ground water flow velocity calculations)?
- Changes in uranium concentrations relative to changes in concentrations of other parameters—Are elevated uranium concentrations associated with changes in other water quality parameters?
- Source term behavior—Do the mineralogy of subsurface soils, solubility of the hazardous constituents of concern, and ground water velocity suggest that source term concentrations are likely to increase or decrease with time?

Water quality and water level data will be reviewed during the data validation process. These results are sent to CDH as the validated data become available and are summarized in an annual site environmental report (ASER) (in

preparation for 1993). Notable trends and variations in water levels and water quality are included in this report. Seasonal fluctuations can be taken into account in trend evaluations. Conformance with or deviations from the conceptual model of the hydrogeological and geochemical environment at and in the vicinity of the Gunnison processing site are also discussed and updated in the ASER.

2.3.5 Anomalous data evaluation

All water quality data will be subject to the rigorous data validation and quality assurance/quality control (QA/QC) procedures outlined in UMTRA SOP 16.3.2 (JEG, n.d.). This procedure provides the criteria for the systematic evaluation of the results of radiochemical and general inorganic chemical analyses and documentation of the evaluation.

If water sampling results exceed the range of expected values, the suspect data will be evaluated to determine the cause. To protect the health of residents downgradient from the Gunnison UMTRA Project site, the following remedial actions are specified for threshold values of uranium:

- As quickly as possible, notify the CDH of any uranium exceedance of 0.020 mg/L in a buffer zone well and 0.200 mg/L in an irrigation well. These potential exceedances would be based on the initial analytical laboratory results (i.e., not yet fully validated data) and would be confirmed when the data are fully validated.
- During the data validation process, a direction for follow-up action would be determined which would call for immediate re-analysis; scheduling follow-up sampling during the next scheduled round, or sooner if necessary; and/or supplying bottled water to the residents.
- If a validated reanalysis or resample demonstrates an exceedance greater than the WSAP action level for uranium and the exceedance is determined to result directly from processing site contamination, appropriate parties will meet to discuss an appropriate course of action to identify an expanded scope of sampling.

Detailed procedures for evaluating anomalous data are included in the WSAP guidance document (DOE, 1993).

2.3.6 Plan modifications and termination of monitoring

Water quality monitoring data will be reviewed annually and the WSAP will be updated and revised, as necessary. Plan modifications are subject to DOE and CDH review.

Additional modifications may be needed after the source term (tailings and RRM) is removed from the mill site. Removal of the source term is a significant change to the aquifer baseline conditions. Previous geochemical investigations (DOE, 1994b) indicate that some constituents that were chemically immobile under acidic ground water conditions may become mobilized if the pH increases (e.g., arsenic, molybdenum, and vanadium). The addition of one or more of these constituents will be considered in annual updates to the WSAP, after surface remedial action is complete.

If a notable increase is detected in contaminant concentration, several activities will be conducted to determine whether the increase indicates a significant change in water quality. Activities to determine the nature and extent of an increase in concentration may include reanalysis, resampling, comparison to other geochemical parameters, and trend analysis. Increases in analyte concentrations occur for various reasons, including 1) artifacts in the process of sample collection and laboratory analysis procedures, 2) changes in background water quality, 3) environmental changes that are unrelated to uranium processing activities, and 4) a single localized pulse in the geochemical environment. If significant increase is perceived to be a health threat, CDH and DOE will consult to evaluate potential actions. Action level criteria for uranium are discussed in Section 2.3.5 and in the appendix to this document.

Ground water monitoring shall not continue after the ground water is determined to be in compliance with UMTRCA ground water cleanup standards. Ground water monitoring will be terminated in consultation with CDH.

3.0 GUNNISON DISPOSAL SITE

3.1 SITE CONCEPTUAL MODEL

The site conceptual model is based on available hydrogeologic information, site reconnaissance, and data from monitor wells installed in the Tertiary gravels and the lahar breccia and volcanoclastic mudflow. Figure 3.1 shows monitor well locations in the vicinity of the Gunnison disposal site. Table 3.1 provides monitor well construction information.

3.1.1 Physiographic setting

The Gunnison disposal site (GUN-08) is on a south-facing slope approximately 1000 ft (300 m) west of the Gunnison County landfill. On-site elevations range from approximately 8000 to 8050 ft (2440 to 2450 m) above mean sea level. The site straddles a drainage divide bounded on the west by Chance Gulch and on the southeast by West Long Gulch.

3.1.2 Geology

Four regional Tertiary hydrogeologic units underlie the disposal site. In descending order these units are 1) upper Tertiary gravels that form an unsaturated zone, 2) lahar breccia and undifferentiated volcanoclastic mudflow that comprise a low permeability semiconfining zone, 3) lower Tertiary gravels that comprise the uppermost (regional) aquifer, and 4) undifferentiated Tertiary gravels to the north where the intervening volcanoclastic mudflow pinches out. A geologic cross section is provided in Figure 3.2. Both the upper and lower Tertiary gravels consist of silty and clayey sand, subrounded cobbles, and welded tuff. The lahar volcanoclastic mudflows and ash flows described above generally form a semiconfining zone that prohibits or retards the movement of ground water downward to the lower Tertiary gravels (uppermost aquifer). In the northern portion of the project site, where the lahar breccia is absent, the upper and lower Tertiary gravels are essentially one hydrogeologic unit (DOE, 1992a).

Generally, a thin veneer of recent alluvium overlies the thick sequence of Tertiary gravels. The thickness of the upper Tertiary gravels overlying the volcanoclastic mudflow stratum ranges from 10 to 94 ft (3 to 29 m) and averages 44 ft (13 m). The lahar volcanoclastic mudflow stratum ranges in thickness from 0 to 210 ft (64 m) and averages 70 ft (21 m). The Tertiary gravels underlying the volcanoclastic mudflow stratum (lower Tertiary gravels) constitute the uppermost aquifer. Material thickness of the uppermost aquifer ranges from 43 to 240 ft (13 to 73 m) and averages 170 ft (52 m).

The Jurassic Morrison Formation, Jurassic Junction Creek Sandstone, and Precambrian metasedimentary and gneissic crystalline rock underly the Tertiary gravels. The units are an average of 300 ft (91 m) below the surface and are from 200 to 370 ft (61 to 110 m) thick.

FIGURE 3.1
LOCATION OF MONITOR WELLS IN THE DISPOSAL SITE VICINITY,
GUNNISON, COLORADO

Table 3.1 DOE monitor well information for the Gunnison UMTRA Project disposal site, Gunnison, Colorado

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	GROUND ELEVATION (FT MSL)	BOREHOLE DEPTH (FT)	BOREHOLE DIAMETER (INCHES)	CASING ELEVATION (FT MSL)	CASING DEPTH (FT)	CASING DIAMETER (INCHES)	SCREEN BEGINNING DEPTH (FT)	SCREEN LENGTH (FT)	FLOW CODE	FORMATION OF COMPLETION
0001	15054.1	12655.8	8012.77	80.00	8.000	8014.71	82.00	4.000	70.00	10.0	O	CL
0002	15185.4	12785.9	8017.64	80.00	8.000	8019.26	82.00	4.000	70.00	10.0	O	CL
0003	15017.4	12830.5	8011.19	80.00	8.000	8013.14	82.00	4.000	70.00	10.0	O	CL
0402	2200.0	3700.0	-	-	-	-	-	-	-	-	N	AL
0403	1900.0	3700.0	-	-	-	-	-	-	-	-	N	AL
0609	14961.0	12563.3	8010.73	150.00	6.000	8012.64	150.00	2.000	138.00	10.0	O	GC
0610	15114.6	12546.5	8014.98	150.00	6.000	8016.54	149.00	2.000	137.00	10.0	O	GC
0611	15087.3	12751.1	8013.73	102.00	6.000	8015.70	99.50	2.000	87.50	10.0	O	CL
0621	15007.7	12559.5	8011.65	183.00	10.000	8013.44	185.00	6.000	130.00	50.0	O	GC
0622	14665.4	12525.1	8008.94	15.0	8.0	8011.02	17.0	2.0	-	-	U	AL
0623	14660.9	12526.8	8009.02	30.0	8.0	8011.11	32.0	2.0	-	-	U	AL
0624	14665.1	12529.8	8009.05	45.0	8.0	8011.05	47.0	2.0	-	-	U	AL
0625	15042.9	12662.0	8012.22	150.00	5.600	8014.72	150.00	2.000	138.00	10.0	O	GC
0626	15177.3	12795.6	8017.10	152.00	5.600	8019.79	150.00	2.000	130.00	10.0	O	GC
0627	15031.5	12963.4	8010.82	153.00	5.600	8013.46	152.00	2.000	135.00	15.0	O	GC
0628	16301.2	12545.4	8050.02	85.00	8.000	8052.11	87.00	4.000	75.00	10.0	O	CL
0629	15745.8	12564.5	8033.63	85.00	8.000	8035.16	83.00	4.000	71.00	10.0	O	CL
0630	14674.5	12524.2	8008.95	137.00	8.000	8010.58	139.00	4.000	127.00	10.0	O	GC
0631	14314.5	12582.4	8028.18	97.00	8.000	8030.18	99.00	4.000	87.00	10.0	O	CL
0632	15077.5	11991.9	7977.62	115.00	8.000	7979.61	117.00	4.000	105.00	10.0	O	GC
0633	15108.6	11659.8	7982.93	112.00	8.000	7984.70	114.00	4.000	102.00	10.0	O	GC
0634	15390.9	11639.6	7975.92	105.00	8.000	7977.87	107.00	4.000	95.00	10.0	O	GC
0635	14496.9	12967.0	8005.95	161.00	8.000	8007.68	163.00	4.000	151.00	10.0	O	GC
0636	15314.3	12960.6	8024.16	85.00	8.000	8024.16	88.00	4.000	76.00	10.0	O	CL
0637	15879.6	12964.6	8042.38	167.00	8.000	8044.30	169.00	4.000	157.00	10.0	O	GC
0638	16210.3	13261.1	8053.11	176.00	8.000	8054.89	178.00	4.000	166.00	10.0	O	GC
0639	15460.0	13443.2	8024.14	157.00	8.000	8026.28	159.00	4.000	147.00	10.0	O	GC
0640	14722.0	13383.8	7990.51	85.00	8.000	7992.30	87.00	4.000	75.00	10.0	O	CL
0650	12337.4	15478.1	8023.75	142.00	4.750	0000.00	000.00	00.000	000.00	000.0	O	GC
0651	15677.7	12652.8	8033.94	150.00	5.125	0000.00	000.00	00.000	000.00	000.0	O	GC
0652	12244.9	16013.2	8036.58	250.00	4.750	0000.00	000.00	00.000	000.00	000.0	O	GC
0653	12477.9	15980.4	8040.03	178.00	4.750	0000.00	000.00	00.000	000.00	000.0	O	GC
0654	12805.8	16282.0	8052.98	150.00	5.125	0000.00	000.00	00.000	000.00	000.0	O	GC
0656	12444.7	16296.7	8045.54	155.00	4.750	0000.00	000.00	00.000	000.00	000.0	O	GC
0657	12686.0	16551.8	8054.70	155.00	5.125	0000.00	000.00	00.000	000.00	000.0	O	GC
0660	13108.5	15325.3	8024.12	145.00	5.125	0000.00	000.00	00.000	000.00	000.0	O	GC
0661	13352.8	15834.2	8040.11	155.00	5.125	0000.00	000.00	00.000	000.00	000.0	O	GC
0662	16646.0	13141.9	8062.28	170.00	5.125	0000.00	000.00	00.000	000.00	000.0	O	GC
0663	16780.3	13543.8	8066.11	171.00	5.125	8068.33	173.00	2.000	171.00	2.0	O	GC
0664	16265.6	13685.1	8049.88	155.00	5.125	0000.00	000.00	00.000	000.00	000.0	O	GC
0665	15799.0	13791.8	8036.61	147.00	4.800	8038.61	147.00	1.250	145.00	2.0	O	GC

Table 3.1 DOE monitor well information for the Gunnison UMTRA Project disposal site, Gunnison, Colorado (Concluded)

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	GROUND ELEVATION (FT MSL)	BOREHOLE DEPTH (FT)	BOREHOLE DIAMETER (INCHES)	CASING ELEVATION (FT MSL)	CASING DEPTH (FT)	CASING DIAMETER (INCHES)	SCREEN BEGINNING DEPTH (FT)	SCREEN LENGTH (FT)	FLOW CODE	FORMATION OF COMPLETION
0666	15358.1	13882.5	8012.17	137.00	5.125	0000.00	000.00	00.000	000.00	000.0	O	GC
0667	15021.3	13371.7	8010.46	134.00	4.800	8012.46	134.00	2.000	132.00	2.0	O	GC
0668	14920.3	13615.2	8005.24	138.00	4.750	0000.00	000.00	00.000	000.00	000.0	O	GC
0669	14449.9	13427.3	7993.51	100.00	5.125	0000.00	000.00	00.000	000.00	000.0	O	GC
0670	14485.1	13887.6	7987.96	82.00	5.6	-	84.	1.25	82.0	2.0	U	GC
0671	17064.7	12681.6	8069.55	155.00	5.125	0000.00	000.00	00.000	000.00	000.0	O	GC
0672	17157.7	13282.5	8074.14	158.00	5.125	0000.00	000.00	00.000	000.00	000.0	O	GC
0673	15163.2	12804.8	8016.32	235.00	5.100	8018.32	235.00	1.250	235.00	2.0	O	GC
0674	12581.0	15831.4	8036.13	150.00	5.125	0000.00	000.00	00.000	000.00	000.0	O	GC
0675	14480.2	16334.6	8041.99	165.00	5.125	0000.00	000.00	00.000	000.00	000.0	O	GC
0676	15388.2	15902.5	7976.29	105.00	5.125	0000.00	000.00	00.000	000.00	000.0	O	GC
0701	15794.28	12880.05	8039.43	407.5	7.88	8041.17	103.0	4.0	102.0	30.0	O	CL
0702	15796.62	12899.77	8039.47	390.0	7.88	8041.72	392.0	4.0	348.0	40.0	O	GN
0703	15102.32	12557.44	8014.14	320.0	7.88	8016.11	229.0	4.0	229.0	120.0	O	GC
0704	15031.28	12603.60	8012.31	254.0	9.88	8014.03	120.0	6.0	107.0	120.0	O	GC
0705	16115.05	13263.33	8050.68	350.0	9.88	8052.78	232.0	6.0	137.0	90.0	O	GC
0706	16105.51	13200.60	8050.08	365.0	7.88	8051.87	226.5	4.0	134.0	90.0	O	GC
0707	16247.86	12502.89	8048.67	372.0	7.88	8050.60	374.0	4.0	360.0	10.	O	GN
0708	16248.32	12523.83	8050.99	170.0	7.88	8052.21	166.7	4.0	154.7	10.0	O	GC
0709	17094.63	10205.98	7926.74	267.0	7.88	7928.68	202.0	4.0	202.0	10.0	O	GC
0710	13590.81	12679.31	8069.47	378.0	7.88	8071.00	332.0	4.0	320.0	10.0	U	GC
0711	14274.66	14744.53	8019.41	271.0	4.0	8021.81	247.5	4.0	235.5	10.0	C	JJ
0712	15096.22	10503.63	7971.06	287.0	7.88	7972.90	286.0	4.0	274.0	10.0	D	GC
0713	14701.33	13387.30	7991.10	272.0	7.88	7992.72	217.0	4.0	205.0	10.0	D	GC
0714	15385.40	16124.14	7889.24	161.0	7.88	7890.96	146.0	4.0	134.0	10.0	D	GC
0715	15450.13	14336.36	8021.21	327.0	7.88	8022.91	174.0	4.0	132.0	40.0	D	GC
0716	17499.18	13216.25	8085.66	395.0	7.88	8087.22	229.	4.0	185.0	40.0	D	GC
0717	16385.62	14728.17	8047.88	352.5	7.88	8049.57	202.0	4.0	160.0	40.0	D	GP
0731	-	-	-	-	-	-	-	-	-	-	N	AL
0732	-	-	-	-	-	-	-	-	-	-	N	AL
0733	-	-	-	-	-	-	-	-	-	-	N	AL
0734	-	-	-	-	-	-	-	-	-	-	N	AL
0735	-	-	-	-	-	-	-	-	-	-	N	AL
0750	18981.04	14686.66	8136.13	309	8	8138.25	298	4	268	30	N	TG
0751	18140.65	15052.62	8065.85	220	8	8068.38	220	4	190	30	N	TG
0801	15509.7	15249.4	7904.72	-	-	-	-	-	-	-	D	NR

FORMATION OF COMPLETION CODE:

GC - CLAYEY GRAVEL OR CLAYEY SANDY GRAVEL
CL - LEAN CLAYS, SANDY CLAYS, OR GRAVELLY CLAYS
GN - GNEISS
JJ - JURASSIC JUNCTION CREEK SANDSTONE
GP - GRAVEL OR SANDY GRAVEL, POORLY GRADED
AL - ALLUVIUM
TG - TERTIARY GRAVELS
NR - NO RECOVERY OF DATA FOR CLASSIFYING

FLOW RELATIONSHIP CODE:

O - ON-SITE
U - UPGRADIENT
D - DOWN GRADIENT
C - CROSS GRADIENT
N - UNKNOWN

FIGURE 3.2
GEOLOGIC CROSS SECTION (NORTH-SOUTH) OF THE DISPOSAL CELL VICINITY
GUNNISON, COLORADO

3.1.3 Hydrology

At the Gunnison disposal site, the uppermost aquifer occurs in the lower portion of a regional Tertiary gravel unit; the top of the aquifer is, on average, 110 ft (34 m) below the disposal cell. A semiconfining zone composed primarily of the lahar gravelly clay volcanic sediment extends from the south and intertongues with the Tertiary gravels beneath the site, as discussed in Section 3.1.2. The semiconfining zone is present beneath the disposal cell but is absent in the northern portion of the site area.

Aquifer testing shows the uppermost aquifer responds as a confined aquifer when the semiconfining zone is present. Because the hydraulic conductivity of the semiconfining zone is very low (2.5×10^{-7} cm/s or less) (DOE, 1992a), it acts as an aquitard to the downward movement of water. The hydraulic conductivity of the Tertiary gravel aquifer ranges from 0.4 to 0.5 ft/day (0.0001 to 0.0002 cm/s). No boundary conditions were observed during a pumping test in the lower Tertiary gravel aquifer and none of the monitor wells completed in the semiconfining zone responded to pumping in the lower Tertiary gravel aquifer. In the lower Tertiary gravel aquifer, the primary (easterly) horizontal hydraulic gradient ranges from 0.004 to 0.014, and averages 0.010. Linear velocities of the uppermost aquifer were calculated by applying Darcy's Law using the calculated range of hydraulic conductivities (0.4 to 0.5 ft/day [0.0001 to 0.0002 cm/s]), hydraulic gradients (0.004 to 0.014), and the assumed porosity value (0.25 for gravelly material) appropriate for the site (Freeze and Cherry, 1979; Davis and DeWiest, 1966). From this calculation, the average linear ground water velocities in the uppermost aquifer (Tertiary gravels) are estimated to range from 2 to 10 ft/yr (2×10^{-6} to 10×10^{-6} cm/s), averaging approximately 7 ft/yr (7×10^{-6} cm/s) (DOE, 1992a).

Ground water recharges the lower Tertiary gravel aquifer by underflow from upland areas south of the site. In the immediate vicinity of the UMTRA Project disposal site, the primary component of flow is toward the east, following the general topographic trend toward Long Gulch. The ground water quality of the Gunnison County landfill is not expected to affect the disposal site, as discussed in the Gunnison surface RAP (DOE, 1992a). Figure 3.3 is a potentiometric map of the lower Tertiary gravel aquifer.

3.1.4 Water quality

Water quality sampling has been conducted at the Gunnison disposal site since 1988. Constituents analyzed during the screening monitoring to determine background and baseline ground water quality included those listed in Section 2.1.4. This list is modified during subsequent sampling events to focus on hazardous constituents related to uranium processing activities.

To achieve compliance with the proposed EPA ground water protection standards at the Gunnison disposal site, the DOE proposes to meet maximum concentration limits (MCL) or background concentrations in the uppermost

FIGURE 3.3
POTENTIOMETRIC SURFACE OF THE UPPERMOST AQUIFER (TERTIARY GRAVELS)
AT THE DISPOSAL SITE, GUNNISON, COLORADO

aquifer (Tertiary gravels) ground water at the point of compliance (POC) (DOE, 1992a). Background water quality in the semiconfining system overlying the uppermost aquifer has been characterized (DOE, 1992a) and monitoring is no longer required. As a result, it will not be discussed in this document.

The pH values in background ground water quality in the uppermost aquifer range from 6.7 to 9.9. TDS concentrations range from 180 to 417 mg/L. Analyses of background ground water samples indicate that concentrations of arsenic, net gross alpha, and radium-226 and -228 slightly exceeded the proposed EPA MCLs in the Tertiary gravels in one or more DOE monitor wells (GUN-08-0609, -0630, -0632, -0640, and -0715). These exceedances are expected to result from naturally occurring materials that leach into the ground water. Table 3.2 presents the proposed POC concentration limits in the uppermost aquifer at the Gunnison disposal site (DOE, 1992a). As the table shows, the median and statistical maximum for arsenic, net gross alpha, and radium-226 and radium-228 are less than their respective MCLs, even though exceedances have been routinely measured in some DOE monitor wells.

3.2 DATA COLLECTION OBJECTIVES

DCOs identify the reasons for collecting data, including regulatory requirements, compliance monitoring, site characterization, risk assessment, and other considerations. DQOs define the manner in which samples are collected, handled, and analyzed. DQOs define analytical support levels; follow standard procedures for water sampling, preservation, and transport and for various other field activities; ensure procedures follow QA and QC protocols; and provide analytical data validation. DQOs for data collection and evaluation activities are stated in the WSAP guidance document (DOE, 1993) and applicable SOPs (JEG, n.d.).

3.2.1 Regulatory requirements

The regulatory requirements for ground water and surface water sampling at the Gunnison disposal site are specified in 40 CFR Part 192 (1993).

3.2.2 Compliance monitoring

Semiannual ground water compliance monitoring is required at the disposal site during surface remedial action construction to comply with the ground water protection strategy and anticipated ground water monitoring program discussed in the RAP (DOE, 1992a). Detailed performance monitoring strategies for the disposal site will be described in the Gunnison long-term surveillance plan (LTSP).

3.2.3 Site characterization

The current water sampling activities are designed to confirm baseline conditions during tailings disposal.

Table 3.2 Summary of background ground water quality and proposed concentration limits for the Gunnison UMTRA Project disposal site

Constituents with MCLs						
Hazardous constituent	Source term concentration	Lab detection limit	MCL	Background		Proposed concentration limit
				Median	Maximum ^a	
Arsenic	19.21 ^b	0.01	0.05	0.03 ^c	0.04	0.05
Cadmium	2.42 ^c	0.001	0.01	0.001 ^d	0.001 ^d	0.01
Chromium	0.74 ^c	0.01	0.05	0.01 ^d	0.01 ^d	0.05
Lead	0.06	0.01	0.05	0.01 ^d	0.01 ^d	0.05
Molybdenum	1.33 ^c	0.01	0.10	0.01 ^d	0.01 ^d	0.10
Net gross alpha ^a	5513.78	NA	15.0	1.32	3.72	15.0
Nitrate	14.4 ^c	1.0	44.0	1.0 ^d	1.8	44.0
Radium-226 and -228 ^a	34.1	0.1	5.0	1.0	1.5	5.0
Selenium	0.23	0.005	0.01	0.005 ^d	0.005 ^d	0.01
Uranium	4.87 ^b	0.003	0.044	0.003 ^d	0.004	0.044
Constituents without MCLs						
Hazardous constituent	Source term concentration	Lab detection limit	MCL	Background		Proposed concentration limit
				Median	Maximum ^a	
Antimony	0.02	0.003	None	0.003 ^d	0.003 ^d	0.003
Beryllium	0.23 ^c	0.01	None	0.01 ^d	0.01 ^d	0.01
Cobalt	19.37 ^c	0.05	None	0.05 ^d	0.05 ^d	0.05
Copper	23.30 ^c	0.02	None	0.02 ^d	0.02 ^d	0.02
Nickel	25.91 ^c	0.04	None	0.04 ^d	0.04 ^d	0.04
Thallium	0.07	0.01	None	0.01 ^d	0.01 ^d	0.01
Tin	0.01	0.005	None	0.005 ^d	0.005 ^d	0.005
Vanadium	1.40	0.01	None	0.01 ^d	0.01 ^d	0.01
Zinc	76.82	0.005	None	0.005 ^d	0.006	0.006

^aDisposal site background ground water statistical maximum.

^bLognormal distribution, mean is geometric.

^cNormal distribution, mean is arithmetic.

^dStatistical values are below laboratory detection limits in Table 8.1 of the *Technical Approach Document* (DOE, 1989).

^aUnits are picocuries per liter.

Note: All units are milligrams per liter unless otherwise noted.

Ref: DOE, 1992a.

NA—Not applicable.

3.3 WATER SAMPLING PLAN

3.3.1 Sampling locations

Seven DOE monitor wells will be sampled in March/April and October 1994 to assess baseline conditions at the Gunnison disposal site during remedial action activities. These monitor wells (GUN-08-0707, -0708, -0713, -0714, -0715, -0716, and -0717) are completed in the Tertiary gravels (uppermost aquifer) (Table 3.3 and Figure 3.1). All of these ground water samples will be filtered. In addition, ground water level measurements will be taken at the following DOE disposal site monitor wells: GUN-08-0609, -0621, -0628, -0630, -0631, -0632, -0633, -0634, -0635, -0640, -0663, -0665, -0709, -0710, and -0712.

Surface water and private well samples will not be collected in the disposal site vicinity. Samples were collected from one location along Tomichi Creek (1988 and 1989) and from two private residences (1989) located more than 1 mile (2 km) northeast of the disposal site. However, additional monitoring at these locations is not pertinent to the DCOs identified in Sections 3.2.1 through 3.2.3.

Table 3.3 DOE monitor well sampling locations for the Gunnison UMTRA Project disposal site and vicinity, Gunnison, Colorado

Well ID	Location	Screened interval (ft bls)	Sampling rationale
GUN-08-0707	Background	360.0 - 370.0	Monitor potential changes in background water quality during remedial action construction.
GUN-08-0708	Background	154.7 - 164.7	
GUN-08-0716	Background	185.0 - 225.0	
GUN-08-0713	Background	205.0 - 215.0	
GUN-08-0714	Downgradient	134.0 - 144.0	Monitor water quality downgradient of the disposal site during remedial action construction.
GUN-08-0717	Downgradient	160.0 - 200.0	
GUN-08-0715	Downgradient	132.0 - 172.0	

Notes:

1. Wells are prioritized from upgradient (background) to downgradient.
bls—below land surface.

3.3.2 Constituent selection

The ground water monitoring program includes collecting and analyzing ground water samples from the monitor wells listed in Section 3.3.1. Ground water samples initially were evaluated for hazardous constituents generally expected to be in or derived from the RRM related to the uranium processing activities. Constituents analyzed during the screening monitoring to determine background and baseline ground water quality included those listed in Section 2.1.4 and Table 2.2. The list of constituents was modified during subsequent sampling events to reflect hazardous constituents related to uranium processing activities at the Gunnison processing site. Based on existing ground water quality data, the current list includes the following constituents:

- Field parameters: alkalinity, dissolved oxygen, oxidation/reduction potential, pH, specific conductivity, and temperature.
- Laboratory analyses: antimony, arsenic, beryllium, cadmium, calcium, chloride, chromium, cobalt, copper, gross alpha, iron, lead, magnesium, molybdenum, nickel, nitrate, potassium, radium-226 and -228, selenium, sodium, sulfate, thallium, tin, TDS, vanadium, uranium, and zinc.

These constituents were chosen based on a comparison between potentially hazardous constituents detected in the tailings source term and the relative concentrations measured in background. Some of these analytes may be omitted from the WSAP in the future, based on further analysis and recommendations in the LTSP. Determination of compliance with ground water regulations and protection of human health and the environment will be based on assessment of trends in ground water quality data in relation to background levels and site-specific conditions.

3.3.3 Sampling frequency

Ground water has been monitored at the Gunnison disposal site since 1988 to establish baseline ground water quality before remedial action. Sampling to date allowed detection of seasonal variation in ground water quality. Sampling will be conducted semiannually during remedial action construction, at a minimum. Performance monitoring frequency will be outlined in the LTSP for the Gunnison disposal site. The Gunnison RAP (DOE, 1992a) reports the following typical monitoring schedule: compliance monitor wells will be sampled semiannually during the construction period, quarterly during the first year after remedial action is completed, semiannually during years two through five, and annually thereafter until the end of the performance monitoring period.

3.3.4 Data interpretation

Water sampling data collected during 1994 will be analyzed and evaluated according to prescribed UMTRA Project procedures and compared with the existing data base. Trends will be analyzed to detect any variations in ground

water flow conditions and ground water quality. Variations will be evaluated and modifications to the sampling plan will be noted, justified, and implemented, as appropriate.

3.3.5 Anomalous data evaluation

If water sampling results are beyond the range of expected values, the suspect data will be evaluated to determine the cause. If the deviation cannot be related to an error in sample collection, analysis, or processes reasonably expected to occur in the hydrogeologic environment, the location will be resampled during the next scheduled sampling round. Resampling will be conducted sooner if there is an urgent need related to potential impact to human health and the environment. Detailed procedures for evaluating anomalous data are included in the WSAP guidance document (DOE, 1993). Potential excursions will be discussed in a site-specific LTSP.

3.3.6 Plan modifications and termination of monitoring

The ground water monitoring program will be carried out during and after the remedial action period, which will be adequate to demonstrate that initial performance of the disposal cell is in accordance with the design requirements presented in the RAP (DOE, 1992a). Future modifications to Section 3.0 of the WSAP will be based in part on the findings of an approved LTSP for the Gunnison disposal site. Sampling locations, constituent selection, sampling frequency, and potential excursions will be discussed in a site-specific LTSP (DOE, 1992b). Future modifications will include but not be limited to the installation of POC wells screened in the uppermost aquifer after remedial action construction (anticipated for 1995). Section 2.3.6 discusses general reasons for plan modifications and termination of monitoring.

4.0 LIST OF CONTRIBUTORS

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40 CFR Part 192, "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings," U.S. Environmental Protection Agency (1993).

FEDERAL REGISTER

52 FR 36000, "EPA Standards for Remedial Actions at Inactive Uranium Processing Sites; Proposed Rule," September 24, 1987.

UNITED STATES CODE

42 USC §7901 *et seq.* Uranium Mill Tailings Radiation Control Act, November 8, 1978.

APPENDIX

**BUFFER ZONE MONITORING PLAN
FOR THE DOS RIOS SUBDIVISION**

GUNNISON, COLORADO

JUNE 1994

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
1.0 INTRODUCTION	A1-1
1.1 Purpose	A1-1
1.2 Background	A1-1
1.3 Scope	A1-2
2.0 SAMPLING LOCATIONS	A2-1
3.0 SELECTION OF ANALYTES	A3-1
4.0 SAMPLING FREQUENCY	A4-1
5.0 INTERPRETATION OF DATA	A5-1
6.0 DATA VALIDATION AND QUALITY ASSURANCE	A6-1
7.0 DATA TRANSMITTAL AND CONFIDENTIALITY	A7-1
8.0 PLAN MODIFICATIONS AND TERMINATION OF MONITORING	A8-1
8.1 Plan modifications	A8-1
8.2 Determination of action levels	A8-1
8.3 Termination of monitoring	A8-1
9.0 REFERENCES	A9-1

LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
1. Private well sampling locations in the vicinity of the processing site, Gunnison, Colorado	A2-3

LIST OF TABLES

<u>Table</u>	<u>Page</u>
1. Private well sampling locations downgradient from the Gunnison UMTRA processing site	A2-2
2. Constituent list for private well sampling locations downgradient from the Gunnison UMTRA processing site	A3-1

LIST OF ACRONYMS AND ABBREVIATIONS

<u>Acronym</u>	<u>Definition</u>
ac	acre
ASER	annual site environmental report
CDH	Colorado Department of Health
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ft	foot
ha	hectare
km	kilometer
m	meter
m ³	cubic meter
mg/L	milligrams per liter
mi	mile
QA/QC	quality assurance/quality control
UMTRA	Uranium Mill Tailings Remedial Action
UMTRCA	Uranium Mill Tailings Radiation Control Act
WSAP	water sampling and analysis plan
yd ³	cubic yard

1.0 INTRODUCTION

1.1 PURPOSE

This report presents a plan for water quality monitoring at the Dos Rios subdivision (including selected locations along Goodwin Lane, Gold Basin Road, and in Dos Rios subdivision Units 2, 3, and the Island Unit) that is intended to satisfy the informational needs of residents who live southwest (downgradient) of the former Gunnison processing site. Water quality monitoring activities described in this report are designed to protect the public from residual contamination that entered the ground water as a result of previous uranium milling operations. Requirements presented in this monitoring plan are also included in the water sampling and analysis plan (WSAP) for the Gunnison Uranium Mill Tailings Remedial Action (UMTRA) Project site. The Gunnison WSAP is a site-specific document prepared by the U.S. Department of Energy (DOE) that provides background, guidance, and justification for future ground water sampling and analysis activities for the UMTRA Project Gunnison processing and disposal sites. The WSAP will be updated annually, as additional water quality data are collected and interpreted, to provide ongoing protection for public health and the environment.

1.2 BACKGROUND

The Gunnison uranium mill tailings site is just south of the city limits of Gunnison, Colorado. The entire site covers 61 acres (ac) (25 hectares [ha]) in the valley of the Gunnison River and Tomichi Creek. Contaminated materials at the Gunnison processing site include the tailings pile, covering about 35 ac (14 ha) to an average depth of 9 feet (ft) (3 meters [m]) and containing 459,000 cubic yards (yd³) (351,000 cubic meters [m³]). Site characterization activities have been conducted at and in the vicinity of the Gunnison processing site since 1983. The results of these investigations indicate that uranium processing activities have affected the ground water quality at and downgradient of the Gunnison processing site and that uranium is the major hazardous constituent of concern.

The following corrective actions are being conducted pursuant to the requirements of the Uranium Mill Tailings Radiation Control Act (UMTRCA) (42 USC §7901 *et seq.*) to satisfy the U.S. Environmental Protection Agency (EPA) standards (40 CFR Part 192 (1993) for cleanup, stabilization, and control of the residual radioactive materials:

- Tailings are being relocated to an engineered disposal cell approximately 6 miles (mi) (10 kilometers [km]) east of the town of Gunnison and 0.4 mi (0.6 km) south of the Gunnison County landfill.

- An alternate supply of potable water is provided to residents whose ground water has been significantly and adversely affected by the uranium processing activities.
- Water quality is monitored at selected locations at and downgradient of the former Gunnison processing site, including selected locations along Goodwin Lane, Gold Basin Road, and in the Dos Rios subdivision (Units 2, 3, and the Island Unit). Water sampling locations are discussed in the WSAP.

A ground water restoration alternative will be selected and implemented for the area affected by previous uranium processing activities.

1.3 SCOPE

Water quality monitoring at Gunnison involves health-protection monitoring in the Dos Rios subdivision. Future ground water monitoring of private domestic wells is advisable in the Dos Rios subdivision for the following reasons:

- Although the DOE provides an alternate water supply system, a buffer zone of representative domestic wells in Unit 2 of the Dos Rios subdivision will be monitored. The buffer zone is downgradient from the area currently covered by the water distribution system.
- The water distribution system is connected to households for potable water consumption and washing. Water needed for irrigation and livestock may be drawn from private irrigation wells. Ground water from these irrigation wells should be monitored to provide assurance that the water quality remains suitable for irrigation and livestock watering.

In addition, the water quality data will provide valuable information on analytical concentration trends that will be useful during the ground water restoration phase of the UMTRA Project.

This buffer zone ground water monitoring plan is designed to be flexible and to take into account changes or trends in uranium concentrations in ground water. It is not intended to be a corrective action plan. However, if significant changes in uranium concentrations are noted, the DOE and Colorado Department of Health (CDH) will review the water quality and hydrogeologic conditions and determine an appropriate course of action. Input from Gunnison County will be solicited through CDH. Data interpretation is discussed in Section 5.0 of this appendix. Plan modifications and action level criteria are discussed in Sections 8.1 and 8.2, respectively.

2.0 SAMPLING LOCATIONS

Ground water and surface water samples will be collected in the vicinity of the former Gunnison processing site, as discussed in the WSAP (Section 2.3.1). The rationale for sampling selected private wells in the Dos Rios subdivision is discussed below.

Previous characterization activities have indicated that elevated concentrations of uranium extend approximately 8100 ft (2500 m) to the southwest (downgradient) of the processing site and into portions of the Dos Rios subdivision (DOE, 1994). Uranium is used to define the extent of contamination because of its mobility in ground water. Elevated uranium concentrations pose a potential health risk to some areas in the Dos Rios subdivision. Private domestic wells in a buffer zone area (Unit 2) and irrigation wells within Unit 3 of the Dos Rios subdivision will be monitored.

Ground water samples will be collected from private wells that supply drinking water west of the Gunnison River (in the buffer zone). These wells are currently beyond the influence of the uranium plume, but will be monitored to ensure that uranium concentrations do not increase in the future.

Wells for private residences that have been connected to the alternate water supply will also be monitored. Although these wells are no longer used to supply potable water, they may be used for irrigation. As a result, water quality monitoring will ensure the water is acceptable for irrigation and livestock.

Table 1 describes recommended sampling locations and the rationale for sampling selected private wells. Figure 1 shows private well sampling locations. Unfiltered samples will be collected from the domestic wells.

Table 1. Private well sampling locations downgradient from the Gunnison UMTRA processing site

Well ID	Description	Sampling rationale
GUN-01-0461	Private batch plant well	Indicates plume migration during seasonal gravel pit dewatering operations. Monitored during surface remediation activities, as a minimum.
GUN-01-0454 GUN-01-0455 GUN-01-0468 GUN-01-0474 GUN-01-0600 GUN-01-0601	Domestic irrigation wells adversely affected by the uranium plume.	Ensures safety of these wells continue for irrigation and livestock uses.
GUN-01-0469 GUN-01-0661 GUN-01-0665 GUN-01-0667 GUN-01-0680 GUN-01-0683	Domestic buffer zone wells in Unit 2 of the Dos Rios subdivision not affected by the uranium plume and downgradient from the area currently covered by the water distribution system.	The DOE is committed to monitoring a buffer zone of domestic wells to ensure that the characteristics of the uranium plume do not change and adversely affect wells in this area.
GUN-01-0660 GUN-01-0679 GUN-01-0684 GUN-01-0685 GUN-01-0686 GUN-01-0687	Alternate domestic wells in Unit 2 of the Dos Rios subdivision not affected by the uranium plume and downgradient from the area currently covered by the water distribution system.	One (or more) of these alternate wells will be sampled only if one (or more) of the primary six buffer zone residents (listed in the row above) are not home. Alternate sampling locations were selected so that six buffer zone wells will be monitored semiannually and so the geographic distribution of buffer zone sampling locations is consistent with that of the primary buffer zone locations (i.e., if a primary location isn't accessible, a neighboring location will be sampled as an alternate).

3.0 SELECTION OF ANALYTES

Water quality samples will be collected from the locations referenced in Section 2.0 (Table 1) and will be analyzed for selected hazardous constituents and indicator parameters. Selection of analytes for these sampling locations is based on information in the Gunnison baseline risk assessment (DOE, 1994) and remedial action plan (DOE, 1992) and a review of historical data. Table 2 provides a list of analytes for domestic well samples.

Table 2. Constituent list for private well sampling locations downgradient from the Gunnison UMTRA processing site

Field parameters:	Alkalinity, dissolved oxygen, oxidation/reduction potential, pH, specific conductivity, and temperature.
Analytes (all wells):	Uranium ^a

^aAll domestic irrigation and buffer zone wells will be sampled semiannually for uranium and selected field parameters, with one exception. One domestic irrigation well (600) will be sampled for the same suite of constituents listed for DOE monitor wells in Section 2.3.2 of the WSAP.

Uranium concentrations will be analyzed in samples from the selected private domestic wells (described in Section 2.0 as irrigation wells or buffer zone wells). Laboratory analyses for parameters other than uranium are not necessary because the DOE monitor well clusters provide sufficient coverage to monitor water quality trends as discussed in the WSAP. However, one private irrigation well (GUN-01-0600) will be monitored annually (in the spring) for the same suite of analytes listed for the DOE processing site (GUN-01) monitor wells in the WSAP (Section 2.3.2) and semiannually (in the fall) for uranium and the field parameters listed in Table 2. If there is a notable change in water quality in either irrigation well GUN-01-0600 or in the DOE monitor well clusters, additional parameters in the domestic irrigation wells and buffer zone wells will be considered.

4.0 SAMPLING FREQUENCY

The ground water monitoring program and the sampling schedule ensure protection of human health and the environment. Variations in historical background water quality measurements, the geochemistry of the source term (tailings pore fluid solution), the ground water flow rate, and the possibility of seasonal variations in ground water quality are considered when the sampling frequency is established.

Sampling is conducted semiannually. The sampling frequency after surface remedial action and during ground water restoration will be dependent upon future site characterization efforts and the ground water restoration alternatives selected. Sampling frequency and duration will be based on contaminant transport travel times and will account for a time lag following completion of surface remedial action. Sections 2.3.3 to 2.3.6 in the WSAP discuss the criteria for continued sampling, such as detailed trend analysis and contaminant transport travel times.

5.0 INTERPRETATION OF DATA

Long-term sampling frequencies and constituents will be determined, based on the following factors:

- Trends in uranium concentrations over time—Was an elevation in concentration a one-time occurrence or part of a statistical trend?
- Spatial changes in uranium concentrations—Does the plume appear to be spreading?
- Source term behavior—Do the mineralogy of subsurface soils, solubility of the hazardous constituents of concern, and ground water velocity suggest that source term concentrations are likely to increase or decrease with time?

Water quality and water level data will be reviewed during the data validation process. These results are sent to CDH as the validated data become available and are summarized in an annual site environmental report. Seasonal fluctuations are accounted for in trend evaluations. Notable trends and variations in water levels and water quality are included in this report. Conformance with or deviations from the conceptual model of the hydrogeological and geochemical environment at and in the vicinity of the Gunnison processing site are also discussed and updated in the annual report.

6.0 DATA VALIDATION AND QUALITY ASSURANCE

All water quality data will be subject to the rigorous data validation and quality assurance/quality control (QA/QC) procedures outlined in the UMTRA standard operating procedure 16.3.2 (JEG, n.d.). This procedure provides the criteria for the systematic evaluation of the results of radiochemical and general inorganic chemical analyses and documentation of the evaluation.

7.0 DATA TRANSMITTAL AND CONFIDENTIALITY

All finalized water quality monitoring data will be transmitted by the DOE to CDH within 4 weeks after the DOE has completed its data validation procedures. CDH will then relay the information to Gunnison County within 4 weeks of receipt of the data from the DOE. All buffer zone and irrigation well data will be treated as confidential by all parties; these data will be summarized in public documents by well number only, in accordance and agreement with the Record Sharing Memorandum of Understanding between the DOE and CDH.

8.0 PLAN MODIFICATIONS AND TERMINATION OF MONITORING

8.1 PLAN MODIFICATIONS

Water quality monitoring data will be reviewed annually and the WSAP will be updated and revised as necessary. Plan modifications will be subject to review by the DOE and CDH.

If a notable increase is detected in a contaminant concentration, several activities will be conducted to determine whether the increase indicates a significant change in water quality. Activities to determine the nature and extent of an increase in concentration may include reanalysis, resampling, comparison to other geochemical parameters, and trend analysis. Increases in analyte concentrations can occur for various reasons, including 1) artifacts in the process of sample collection and in laboratory analysis procedures, 2) changes in background water quality, 3) environmental changes that are unrelated to uranium processing activities, and 4) a single localized pulse in the geochemical environment. If a significant increase is perceived to be a health threat, CDH and DOE will consult to evaluate potential actions. Action level criteria are discussed in Section 8.2.

8.2 DETERMINATION OF ACTION LEVELS

The DOE will immediately notify CDH if the uranium concentration of any well in the buffer zone (Dos Rios subdivision, Unit 2) (confirmed through Technical Assistance Contractor validation QA/QC procedures) exceeds 0.020 milligrams per liter (mg/L) and if the uranium concentration in any irrigation well exceeds 0.200 mg/L. After notification to CDH, the contaminant levels and distribution will be evaluated as discussed in Section 8.1. Potential actions will then be determined.

As an interim measure, bottled water will be supplied if a uranium concentration measured in a buffer zone well sample exceeds the EPA health advisory level of 0.030 mg/L, pending determination of the nature and extent of the exceedance. The action levels for flagging data, notifying the CDH, providing temporary bottled water, and providing a permanent solution are tied to proposed EPA drinking water standards for radionuclides, EPA health advisory levels for drinking water constituents, and proposed EPA ground water protection standards. Should these standards and/or health advisory limits change in the future for the contaminants of concern, the buffer zone monitoring plan for the Dos Rios subdivision and the WSAP will be reevaluated.

8.3 TERMINATION OF MONITORING

Ground water monitoring shall not continue after the ground water is determined to be in compliance with the ground water cleanup standards promulgated under UMTRCA. Ground water monitoring in the Dos Rios subdivision will be terminated in consultation with CDH.

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- DOE (U.S. Department of Energy), 1994. *Baseline Risk Assessment of Ground water Contamination at the Uranium Mill Tailings Site Near Gunnison, Colorado*, prepared by the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.
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UNITED STATES CODE

- 42 USC §7901 *et seq.* Uranium Mill Tailings Radiation Control Act, November 8, 1978.

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